APPENDIX I
SCIENTIFIC PEER REVIEW PANEL FINAL REPORT AND DISTRICT RESPONSE

FIRST DRAFT
FINAL REPORT

By:

THE TECHNICAL DOCUMENTATION TO SUPPORT DEVELOPMENT OF MINIMUM FLOWS FOR THE ST. LUCIE RIVER AND ESTUARY SCIENTIFIC PEER REVIEW PANEL

To:
South Florida Water Management District
Water Supply Division
P.O. Box 24680
West Palm Beach, Florida 33416-4680

Panel Chair, Report Editor:

Mark S. Peterson, Ph.D.
Department of Coastal Sciences
College of Marines Sciences
The University of Southern Mississippi
703 East Beach Drive
Ocean Springs, Mississippi 39564

Panel Members:

Edward J. Buskey, Ph.D.
The University of Texas at Austin
Marine Science Institute
750 Channelview Drive
Port Aransas, Texas 78373

Wu-Seng Lung, Ph.D., P.E.
School of Engineering and Applied Science
The University of Virginia
Thornton Hall
Charlottesville, Virginia 22903-2442

July 10, 2001

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report is an independent peer review of the scientific and technical data and methodologies supporting the minimum flows and levels (MFL's) of 21 cfs for the North Fork and 7 cfs for the South Fork of the St. Lucie River and Estuary (SLE) outlined in the "Draft Technical Documentation to Support Development of Minimum Flows for the St. Lucie River and Estuary" published on 21 May 2001 (SFWMD, 2001). Flows less than these suggested MFL's would cause "significant harm" to the SLE. The Draft Technical Document describes the SLE, the process and basis for establishment of minimum flows and levels, legal and policy issues, and definitions of levels of "harm". A small number of other appropriate documents were provided by the District for consideration by the expert panel. The peer review panel was charged to review the document on its technical basis of MFL criteria only, policy decisions and assumptions were not subject to peer review. Based on the panel's review, the criteria and data used by the District was the best available information at the time of the report. Two major issues surfaced with the expert panel: 1) salinity model development and validation, and 2) connection of the oligohaline zone and the VEC.

Overall, the data and approaches to analyzing the data and the modeling are scientifically valid. However, salinity data are needed to support the hydrodynamic modeling effort since no salinity data from the study area are presented in the Draft Technical Documentation. It is recommended that additional modeling results of salinity be presented in the Final Technical Documentation to document model calibration using available salinity data. Quantitative assessment of the goodness-of-fit between the model results and salinity data must be included. There is no mention of the linkage between the watershed model and the hydrodynamic model in the Draft Technical Documentation. An ideal simulation scenario to fully validate the hydrologic and hydrodynamic model simulations would be to perform a 10-year simulation to reproduce the long-term salinity data from 1989 to 1999. Salinity data are available from the SWIM program for the SLE. The most serious ecological deficiencies in this plan are the lack of direct evidence connecting the oligohaline zone to tangible evidence of enhancement of VEC's and the lack of consideration of other potential benefits, such as nutrients and organic matter. These are associated with the freshwater inflows to the estuary and may be required to maintain estuarine productivity. These deficiencies are not associated with any flaws in the proposed minimum flow criteria, but are simply due to a lack of information on this particular estuarine system.

The process of adaptive management requires a clear management goal (such as, maintaining a certain area or volume of oligohaline habitat during certain seasons), monitoring (which can be restricted to the managed segment), determining if the expected changes are occurring (within an acceptable range of uncertainties), and re-evaluation of the MFL's on short-term intervals. Without knowing how much (or when) oligohaline habitat is required to maintain or enhance productivity in the SLE, there is no clear, compelling minimum flow rate. Therefore, setting the management goal will require evaluation of the biological communities and environmental setting, and policy decisions on which natural resources are to be conserved, protected, or optimized. Monitoring could be economical because the main variables of interest (salinity and DO) are inexpensive to measure and are automated This focused monitoring activity would allow for annual evaluation and refining of the MFL's

INTRODUCTION

Purpose

The purpose of this report is to present findings of an independent scientific peer review of the scientific and technical data and methodologies supporting the proposed MFL for the St. Lucie River and Estuary published on 21 May 2001 by the South Florida Water Management District ("District"). Specifically, we reviewed a scientific report prepared by the District entitled "Draft Technical Documentation to Support Development of Minimum Flows for the St. Lucie River and Estuary" (SFWMD, 2001). The technical report was accompanied by copies of a number of its key supporting references. An independent peer review is defined by Florida Statutes to mean the review of scientific data, theories, and methodologies by a panel of independent, recognized experts in the fields of hydrology, hydrogeology, limnology, and other scientific disciplines relevant to the matters being reviewed. The District was directed by the Florida legislature to establish minimum flows for surface water courses and minimum levels for aquifers and surface waters. Under the statute, a minimum flow for a given surface water course is the limit at which further withdrawals would be significantly harmful to the water resource or ecology of the area. The minimum water level is the level of the ground water in an aquifer, or the level of the surface water, at which further withdrawals would be significantly harmful to the water resource of the area.

Charge

The charge for the peer review panel was to review scientific and technical data and methodologies used in the development of the proposed MFL for St. Lucie River and Estuary (SLE). In addition to copies of a number of the key supporting references used by the District, the panel was also provided with questions from the public obtained at the 8 June 2001 Rule Development Workshop, in writing and orally at the 28 June 2001 workshop, and via the web conference board that has not been initially provided by the District. All panel requests for information were met by the District in a timely manner.

Development of the proposed MFL's was a result of legal and policy interpretations of the MFL statue. The panel was asked to treat legal and policy considerations as assumptions or conditions for the technical review and therefore not within the scope of the review process. Statue requires the use of the "best available information" for calculating the MFL's.

Specifically, the panel was asked to evaluate the methods used by the District for the MFL's by completing five Tasks:

Task 1. Review Background Materials, Write Preliminary Review and Questions for Staff-

Consideration of this task required addressing both general and specific questions outlined in the Charge.

General questions:

1. Does the MFL document present a feasible scientific basis for setting initial minimum

flows and levels within the above water resource? Are the approaches or concepts described in the document scientifically sound based on "best available information"?

2. Are the proposed criteria logically supported by "best available information" presented in the main body of the document? What additions, deletions or changes are recommended by the Expert to enhance the validity of the document?

3. Are there other approaches to setting the criteria that should be considered? Is there available information that has not been considered by the authors? Is so, please identify specific alternatives to setting the MFL's and the data available to validate the alternative approach.

Specific technical questions evaluated include the appropriateness of:

- the use of the Valued Ecosystem Component (VEC) approach for establishing an MFL;
- the choice of oligohaline habitat as an MFL VEC;
- the completeness of literature review for the intended purpose;
- the freshwater flow links to biological communities (has a scientific linkage been clearly established?);
- the use and interpretation of two-dimensional hydrodynamic-salinity modeling of the effects of various freshwater flow regimes in the estuary;
- the movement and location of oligohaline habitat;
- the positive and negative effects of various freshwater flow regimes on the river and estuary; and
- the freshwater flow regime proposed during drought conditions.

Task 2. Participate in a Field Trip of the Ecosystem - District staff led a helicopter flight for a large-scale overview of the watershed and boat trip for a close-up view of the SLE ecosystem.

Task 3. Public Workshop - A public workshop was held where District staff made presentations about the preparation, development and interpretation of the MFL document. The public was also invited and when appropriate asked specific questions and made informed statements about the document and MFL plan. After all input and discussion, the review panel met in executive session and developed a detailed outline and assigned writing tasks to be eventually completed through the District's web board.

Task 4. Draft Peer Review Panel Report; Panel Findings - The draft final report is a composite of the opinions of the scientific panel based on the MFL document, knowledge gained from the field trip, discussions at the workshop and input from the public. This document was developed via the executive session and subsequent web board communications of the panel.

Task 5. Final Peer Panel Report: Assembly, Editing and Delivery to District - The panel Chairperson compiled the final peer panel report, make any necessary changes, conduct an internal panel review, get sign-off from the panelists and assemble to final product for delivery to the District via the web board.

Panel Organization

The peer review panel was composed of three academic scientists with complementary expertise: Dr. Mark S. Peterson (fish ecologist with expertise in oligohaline habitats); Dr. Ed Buskey (estuarine ecologist with expertise in hypersaline habitats) and Dr. Wu-Seng Lung, P.E. (environmental engineer with expertise in water quality modeling).

Panel Activities

The peer review panel conducted all its work according to the terms of the Florida sunshine law. All meetings and communication among panelists were at a noticed open meeting or via the District's web board, which was available for public viewing. The panel met to consider the minimum flow during the following dates:

Date (2001)	Activity
June 5	Review draft and materials/written response
June 27	Field trip to SLE
June 28	Public workshop and executive session
July 18	Draft final report due
July 31	Final report due (Chairperson only)

REVIEW OF MODELING STRATEGY

Salinity Data to Support Hydrodynamic Modeling

Salinity is one of the key factors in assessing the ecological impact of minimum flows in the SLE. Sudden salinity variation due to alteration in freshwater inflow can significantly affect the brackish water biota. It is essential that the dynamic changes of the location of the oligohaline zone be accurately predicted under a wide range of freshwater flow conditions in the system. Salinity data is needed to support the hydrodynamic modeling effort. No salinity data from the study area are presented in the Draft Technical Documentation to Support the Development of Minimum Flows for the St. Lucie River and Estuary (SFWMD, 2001). A review of the historical data has indicated that salinity has been routinely monitored in the SLE since 1989 under the SWIM program (Chamberlain and Hayward, 1996). Figure 1 shows the monitoring stations in the study area where salinity and nutrient data have been collected during the past decade.

Spatial distributions of salinity along the SLE are similar to those observed in many coastal plain, partially mixed estuaries. Figure 2 shows the longitudinal profile of surface salinity in the SLE under high and low inflows. Note that Stations SE00 to SE03 are in the lower estuary (see Figure 1). Stations SE05 and SE06 are in the North Fork while Stations SE08 and SE10 are in the south direction under high inflow conditions. In fact, the oligohaline zone occurs at about 5

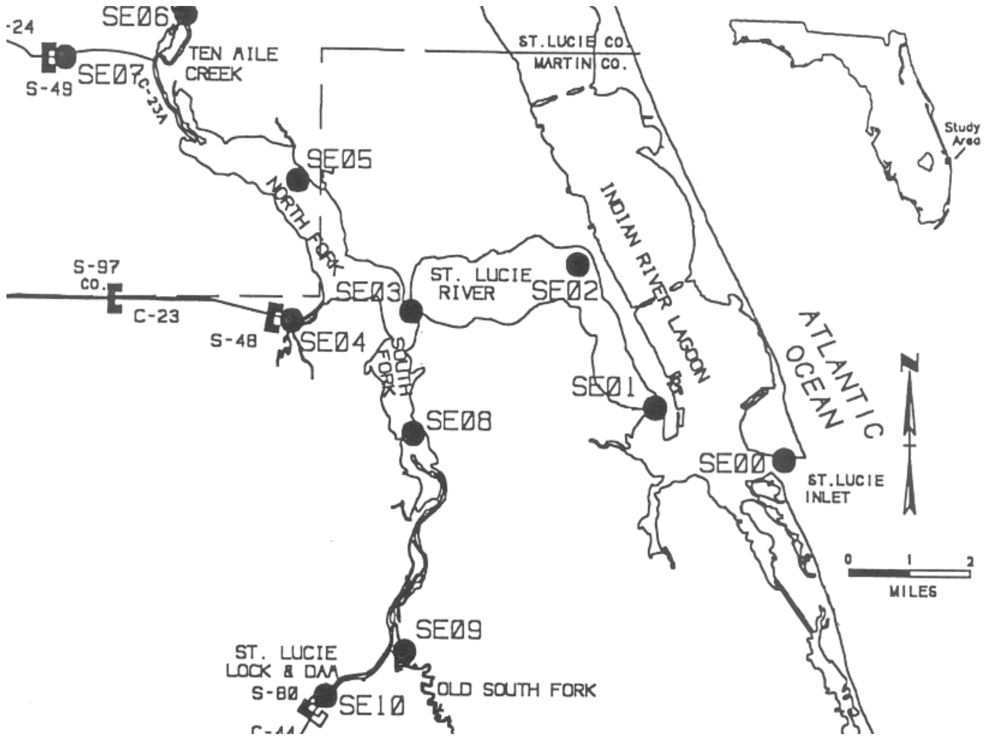

Figure 1. St. Lucie River and Estuary Sampling Stations (SE00-SE10)

miles from the mouth of the river. Under low inflows, the salinity intrusion reaches very far upstream with the oligohaline zone in the North Fork starts at about 14 miles from the mouth.

Vertical salinity gradients strongly affect the dissolved oxygen (DO) concentrations in the SLE. Fifty-one percent of the below-2 mg/L DO cases were associated with high salinity stratification values between 2 and 4 ppt/m (Chamberlain and Hayward, 1996). However, these typically occurred at the tributary heads, when temperature was high and circulation was minimal (i.e., no inflow). Although DO conditions greatly improved at the tributary heads during high-flow circulation, the remainder of the estuary experienced a DO sag caused by strong salinity stratification.

Hydrological Modeling of the Watershed

The hydrological simulations were performed using the HSPF modeling framework for the St. Lucie River Basin. Model results of stages and flows match the data well. It is recommended that statistical analyses be conducted to quantify the goodness-of-fit between the calculated and measured daily flows at the three structures: S-49, S-97, and S-80. The calculated daily flows should be used in the hydrodynamic model to drive the salinity simulations. In addition, a quantitative analysis of the model results vs. data (flow and temperature) should be performed. The latest watershed modeling effort for the Chesapeake Bay Program may be consulted for a variety of statistical analyses for the HSPF model results vs. data. The Chesapeake Bay Watershed Modeling Website is http://www.chesapeakebay.net/temporary/mdsc/index.htm.

Hydrodynamic Modeling

Appendix F of the Draft Technical Documentation presents two methods to quantify salinity distributions in the SLE: 1-D analytical solution and 2-D RMA model. Following the discussion with the District staff at the public workshop on June 28, it is clear that the 2-D RMA model is the only in-house tool currently used for the SLE. It is also understood that the model's upstream boundary will be extended further upstream to the location where the low inflow of 20 cfs is established in the North Fork of the St. Lucie River. It is recommended that additional modeling

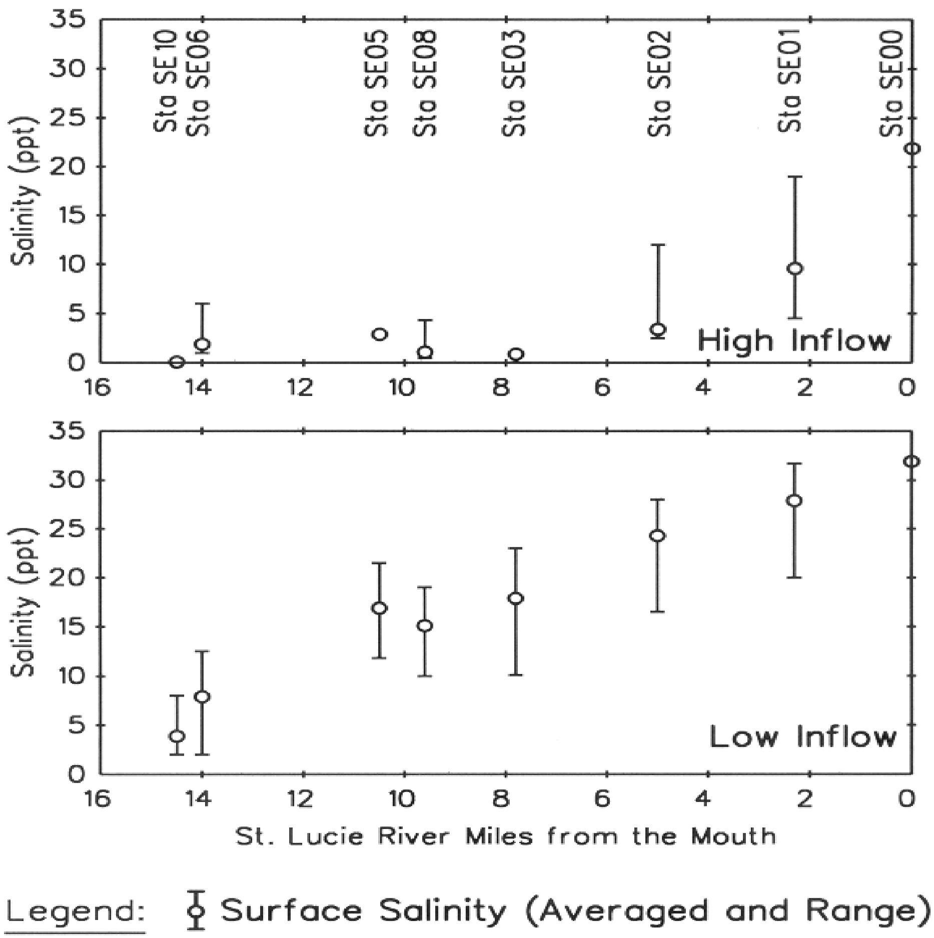

Figure 2. Salinity Data – St, Lucie River and Estuary (from Chamberlain and Hayward, 1996)

results of salinity be presented in the Final Technical Documentation to document model calibration using available salinity data. Quantitative assessment of the goodness-of-fit between the model results and salinity data must be included.

There is no mention of the linkage between the watershed model and the hydrodynamic model in the Draft Technical Documentation. An ideal simulation scenario to fully validate the hydrologic and hydrodynamic model simulations would be to perform a 10-year simulation to reproduce the long-term salinity data from 1989 to 1999. [Salinity data are available from the SWIM program for the St. Lucie River Estuary.

RESPONSE TO CHARGE

Reasonableness

The general approach of the methodologies used in the Draft Technical Document (SFWMD, 2001) was sufficiently developed, but a number of assumptions were made and not clearly outlined or defended. The District, however, did not sufficiently detail other impacts of the MFL's on the system as outlined below. These must be considered in the revision of this document.

The approach did consider and was developed based upon methods used in other areas of the country. Given the deficiencies outlined in this report, the expert panel believed the document taken in total is a well-developed start at dealing with the MFL issue for SLE. Generally, a management objective was stated and the estimated response can be judged successful within an acceptable range of error. The expert panel, however, has provided some additional metrics and approaches that should be considered in their Final Technical Document.

Editorial Comments

The expert panel has pointed out some needed editing of the Technical Document in our initial written responses. Additionally, there is some cited literature (Cox *et al.*, 1994; Kemp *et al.*, 1983; Twilley *et al.*, 1985; Cooper and Ortel, 1988; Sculley, 1996; a large number in Table 4-1and and probably other Tables as well) that does not appear in the Literature Cited section. Additionally, there are a number of fish and shellfish names (both scientific and common names) that are not correct in Table 4-1 (*sensu* Robins *et al*. 1991; Perez Farfante and Kensley 1997). These need to be corrected in the Final Technical Document.

Table name	Correct name
Striped moharra	Striped mojarra
Moharra	Mojarra
Mosquito fish	Mosquitofish
Gombiosoma bosci	*Gobiosoma bosc*
Micropogon undulates	*Micropogonias undulates*
Panaeus aztecus	*Farfantepenaeus aztecus*

External Comments on MFL

During the public meeting a representative of the River Initiative presented the groups concerns about the Technical Document. They are concerned that 1) the spirit of the document of setting the MFL as a “starting point” may not survive imminent rule development and eventual legal wording, 2) that setting the MFL so low may lead to greater use-permitting, and 3) that the MFL’s based on the natural systems model during dry times is actually lower than the long-held belief of larger flows during dry times than observed today. In general, the River Initiative feels the 21 May 2001 document as written is a good starting point. All of the above concerns appear an issue of “policy” and are not in the purview of the expert panel (SFWMD, 2001). These should be addressed by the District in the Final Technical Document prior to setting the final MFL’s.

Written public comments and questions obtained at the 8 June 2001 Rule Development Workshop were provided to the expert panel during the site visit. The concerns were 1) use of the word “oligohaline” instead of oligosaline; 2) targeting only the SLE in St. Lucie County with little discussion of the SLE in Martin County; 3) quality of the fresh water entering the SLE, and 4) the perceived omission of a serious discussion concerning the Upper east Coast regional Water Supply Plan’s indication that 84% of the fresh water in the planning area is being used for agriculture, leaving only 16% for consideration.

Item #4 above appears to be a “policy” issue whereas the other three items can be addressed in this report. The term “oligohaline” is the correct term and is grounded in estuarine science. Clearly there are more data available from the St. Lucie County portion of the SLE (North Fork) than the Martin County portion (South Fork). The data and simulations for South Fork should be considered preliminary in nature. Finally, the water quality issues raised are also a concern of the expert panel and should be addressed in the Final Technical Document as indicated below.

Deficiencies

Minimum flow recommendations for the SLE are set based on flows that would cause harm or significant harm to the predefined VEC. The draft report sets the VEC for the SLE as the establishment of an oligohaline zone (salinities of 0.5 to 5 ppt salinity), with the implicit assumption that establishment of this zone will protect and encourage development of biota that comprise a loosely defined set of VEC’s. The most serious deficiencies in this plan are the lack of direct evidence connecting the oligohaline zone to tangible evidence of enhancement of VEC’s and the lack of consideration of other potential benefits, such as nutrients and organic matter, that are associated with the freshwater inflows to the estuary and may be required to maintain estuarine productivity. These deficiencies are not associated with any flaws in the proposed minimum flow criteria, but are simply due to a lack of information on this particular estuarine system. These can be corrected with appropriate research projects, and an adaptive management strategy is strongly recommended by the expert panel such that minimum flow requirements could be altered if necessary.

Connection of Oligohaline Zone to VEC's

There has been relatively little direct study of value, productivity and species associated with oligohaline environments. However, it is clear that insufficient freshwater inflow can have important negative impacts on estuarine systems (e.g. Holmquist *et al*., 1998). In the documentation provided to the expert panel, emphasis seemed to be placed on the potential for using submerged aquatic vegetation (SAV) or oyster reefs as VEC (see St. Lucie Estuary Historical, SAV, and American Oyster literature review). These VEC have been used in other estuaries, and both components not only have value themselves for primary and secondary production of estuaries, but also provide important habitats for a wider range of organisms. However, our tour of the SLE revealed that shallow benthic habitat appropriate for SAV or oyster beds is very limited in the North Fork of the SLE, which has steep banks after being dredged to aid in flood control. It was clear after discussion with District personnel, that productivity in the SLE is thought to be primarily from phytoplankton, so although enhancement of SAV and oysters may be a good restoration goal, these components may have limited value as VEC is the SLE in terms of setting MFL's.

There has been less study of the importance of oligohaline zones to plankton based estuarine communities. Laboratory studies clearly indicate that most estuarine and marine phytoplankton have clear salinity preferences, with maximum growth rates occurring over specific salinity ranges, and species diversity declining under both oligohaline and hypersaline conditions (Brand, 1994; Buskey *et al*., 1998). There is no clear evidence that shows oligohaline zones provide for enhanced quality or quantity of phytoplankton production. There are highly productive species of zooplankton that appear capable of inhabiting the oligohaline zones of estuaries (e.g. species of the genus *Acartia* and *Eurytemora*) in subtropical environments, although high flows of freshwater into estuaries tend to physically displace estuarine zooplankton and replace them with freshwater zooplankton community, although when salinities increase the estuarine species return (Gillespie, 1971; Matthews, 1980; Kalke, 1981). However, oligohaline salinities are not favored by these species, and their biomass and productivity maxima are not associated with these salinity ranges (Heinle, 1966; Farmer, 1980; Roddie *et al*., 1984).

Planktonic organisms tend to be physically displaced along with oligohaline and mesohaline waters during high flow events, so they are rarely exposed to rapid changes in salinity. This is not true for benthic plants and animals such as SAV and oysters that remain in place as salinities of their surrounding waters change. The minimum flow criteria for the SLE aims to establish an oligohaline zone as a VEC, but the location of this oligohaline zone is flexible, and will move up and down the estuary as flows increase above the minimum. The range of salinity tolerances and the effects of rate of change of salinity on fixed benthic VEC such as SAV and oyster beds needs to be considered.

Tidal-River Nekton

There is, however, considerable descriptive data on the importance of oligohaline habitat to both freshwater and estuarine-dependent nekton during all or part of their life history. The nekton distributions in the SLE are important because they define freshwater and oligohaline assemblages that can be influenced by the minimum flow rule. Tidal rivers are defined as water bodies that receive freshwater from areas other than runoff (from the upstream watershed), are flushed to some extent during a tidal cycle and are subject to salt intrusion from downstream areas (Hackney *et al*., 1976). These important tributaries are part of the estuarine landscape that is known for its biodiversity and productivity worldwide (Gunter, 1967; Szedlmayer, 1991; Peterson and Ross, 1991; Wagner and Austin, 1999).

Many estuarine-dependent fishes and crustaceans like snook (*Centropomus undecimalis*), red drum (*Sciaenops ocellatus*), and pink shrimp (*Farfantepenaeus duorarum*), for example, utilize all or a portion of tidal rivers as nursery habitat. These estuarine-dependent transients, tidal river residents like members of the families Atherinidae (silversides), Cyprinodontidae (killifishes) and Poecillidae (livebearers), and secondary freshwater species like sunfish and black basses (Centrarchidae), and catfishes (Ictaluridae) comprise the fish fauna of low salinity tidal rivers. There is a strong relationship between salinity and size in a great number of estuarine-dependent transient fishes and crustaceans in estuaries and coastal ecosystems (Sykes and Finucane, 1966; Rogers *et al*., 1984; Szedlmayer, 1991; Peebles and Flannery, 1992; Wagner and Austin, 1999), indicating that young developmental stages of organisms are found abundantly in low salinity habitats.

Seasonal variation in a number of abiotic parameters is a common pattern in estuarine systems. In fact, recruitment events of many estuarine organisms are timed to take advantage of this variability. For example, Sykes and Finucane (1966) determined that Tampa Bay species of commercial importance varied seasonally and spatially within the bay, which corresponded to seasonal salinity variation. Hughes (1969) determined that postlarval pink shrimp (*F. duorarum*) could perceive and respond to salinity changes as small as 1 ppt. He found postlarvae were more active in high salinity and that in low salinity they dropped to the substratum whereas juveniles were positively rheotactic when Anormal@ seawater salinities were encountered, thus swimming against the current. When salinities were lower (ebb tide), juvenile pink shrimp swam downstream with the current. This mechanism facilitated offshore movement of the larger pink shrimp. These data illustrate the need to maintain normal freshwater flows from tributaries to bays for recruitment of this commercially important crustacea. Perez (1969) also determined that juvenile spot (*Leiostomus xanthurus*) and Atlantic croaker (*Micropogonias undulatus*) both responded to gradual rates of salinity change by increased swimming compared to fixed or severely fluctuating salinity conditions, allowing young fishes to move into areas in the estuary where salinity fluctuation was gradual or constant compared to severely fluctuating. Rogers *et al*. (1984) determined that individuals of several seasonal recruiting species (Atlantic flounder, *Paralichthyes lethostigma*, Atlantic menhaden, *Brevoortia tyrannus*, silver perch, *Bairdiella chrysoura,* and spot) appear to move preferentially to primary nursery zones at the most inland locations in Georgia, subsequently moving to deeper or more saline waters as they grow. Recruitment was timed to spring freshwater flows into the marsh. In the Tampa Bay area, Peebles and Davis (1989) determined that peak spawning activity occurs between March and August in the Little Manatee River with early juvenile estuarine-dependent species (*C. undecimalis*, spotted seatrout, *Cynoscion nebulosus*, and *S. ocellatus*) concentrated in low salinity areas (> 75 % abundance in < 18 ppt. Finally, Longley (1994) determined that estuaries are by definition dynamic and water management activities should attempt to parallel those dynamic patterns of freshwater inflow A...within the productive range, both seasonally and annually...@. AThe seasonal timing of freshwater inflows is most important because adequate inflows during critical periods of reproduction and growth can produce greater benefits than constant inflows throughout the year@.

Water Quality Impacts of MFL’s

One of the serious deficiencies in the Draft Technical Documentation is the lack of discussion on the water quality impact. It should be pointed out that several water segments in the St. Lucie River Basin are listed in the 303(d) list for water quality impairment: St. Lucie Estuary, St. Lucie Canal, and South Fork St. Lucie River. In light of the statement by Chamberlain and Hayward (1996) that more stable, lower flows will improve water quality in the SLE, it is important to quantify the water quality impact of lower inflows. While it is logical to approach MFL’s from a point of view of maintaining habitats within certain salinity ranges, and since freshwater inflow to estuaries also brings with it more that fresh water (e.g. nutrients, dissolved and particulate organic matter, inorganic particles including silts, clays, sand), the effects of altering these inputs should also be considered.

A water quality model is an appropriate tool to perform such an analysis. In particular, the water quality model can be designed to address the following questions related to MFLs:

1. What are the nutrient loads under the minimum flows?
2. How does the SLE respond, in terms of algal growth and dissolved oxygen, to a prolonged period of minimum flows?
3. Under low inflow conditions, the salinity levels become well mixed in the water column, yet further salinity intrusion will take place. On the other hand, the water column becomes more stratified under high inflows. Would this intensify the dissolved oxygen stratification in the water column?
4. What is the role of sediments in contributing to benthic oxygen demand and nutrient fluxes when the bottom layer of the water in the estuary becomes anaerobic?

Perhaps modeling studies in the St. Lucie Estuary TMDL effort should be consulted for the SLE MFLs. Although the St. Lucie Estuary TMDL is to be completed, it is recommended that their results should be incorporated into the SLE MFLs in the future.

Nutrients

Freshwater inflow to the SLE may provide an important source of inorganic nutrients that support the primary productivity of this system. While excess nutrient may be a concern in terms of eutrophication and potential for hypoxic or anoxic environments associated with organic loading, the SLE also depends on a minimum input of new nutrients to this system to maintain productivity (Nixon, 1981). It seems unlikely that short-term limitation of new nutrients to the SLE would lead to a reduction in productivity that would be harmful to the system, but the role of this input of new nutrients should be considered in determining MFL’s. The timing of freshwater inflows can also impact the nature of the phytoplankton community in an estuary.

There is good experimental and theoretical evidence that a pulsed freshwater release will ultimately result in greater production of fish and larger consumers compared to when water is allowed to "trickle" into the system. larger planktonic primary producers are able to sequester a greater proportion of growth-limiting nutrients when they are presented at elevated concentrations over a short time interval (Suttle *et al.*, 1988), therefore a pulsed nutrient supply will select for larger phytoplankton (Turpin and Harrison, 1980; Suttle *et al.*, 1987). This results in a food-web based on large-size phytoplankton, which is more efficient in transferring nutrients and energy to higher trophic levels than is a food-web based on pico- or nanoplankton (Suttle *et al.*, 1990).

DOC and POC

Input of dissolved (DOC) and particulate organic carbon (POC) to estuaries can come from terrestrial or riverine sources, as well as from primary and secondary production within the estuary. Terrestrial inputs of DOC and POC to the SLE will be impacted by minimum flow requirements. At this point there is no information available as to the relative importance of this imported carbon to the productivity of the SLE, but it should also be considered when setting minimum flows. Relative importance of phytoplankton, seagrasses and terrestrial carbon can be estimated by examining the stable carbon isotope ratios of POC and various marine organisms (e.g. Fry and Sherr, 1984). Reduced import of organic matter could also in turn affect rates of benthic nutrient flux and biological oxygen demand of sediments.

Inorganic Particles and Sediment Quality

Another factor to consider may be the impact of reduced flow on accumulation of low-quality muck sediments. By reducing imported organic matter and nutrients, organic loading of muck type sediments in the SLE may be reduced, and frequency of hypoxic and anoxic events might be reduced. Alternately, reduced flow might also encourage the accumulation of muck sediments in areas where they would be scoured and carried down stream during periods of higher flow.

CONCLUSIONS AND RECOMMENDATIONS

The expert panel thinks the Draft Technical Document (SFWMD, 2001) is an appropriate “conceptual” approach to the issue of establishing MFL’s but it lacks in important data sets and makes a number of unstated or poorly understood assumptions (e.g., connection of oligohaline and VEC’s, water quality impacts, importance of water flow to the estuary in additions to its role in salinity, etc.). These are outlined in detail above and should be considered by the District when developing the Final Technical Document.

The process of adaptive management requires a clear management goal (such as, maintaining a certain area or volume of oligohaline habitat during certain seasons), monitoring (which can be restricted to the managed segment), determining if the expected changes are occurring (within an acceptable range of uncertainties), and re-evaluation of the MFL's on short-term intervals. Without knowing how much (or when) oligohaline habitat is required to maintain or enhance productivity in the SLE, there is no clear, compelling minimum flow rate. Therefore, setting the management goal will require evaluation of the biological communities and environmental setting, and policy decisions on which natural resources are to be conserved, protected, or optimized. Monitoring could be economical because the main variables of interest (salinity and DO) are inexpensive to measure and are automated This focused monitoring activity would allow for annual evaluation and refining of the MFL's

Terminology

The expert panel suggests that a listing of terms, definitions and abbreviations be incorporated into the revised technical document. In particular, the expert panel would like to see more clear definitions of harm, significant harm and serious harm if possible. We noted some differences in the Draft Technical Document and how staff used these terms during our site visit. The expert panel noted that is some places in the document the definition of significant harm referred to "seasons" whereas in other places it refers to "years." Clearing these issues up will make it easier for the non-expert to understand and appreciate the Final Technical Document.

Future Monitoring

-compare the rates of primary productivty and phytoplankton biomass of the oligohaline and mesohaline zones of the SLE.

-compare zooplankton biomass in oligohaline and mesohaline zones of the SLE.

-investigate tolerances of sedentary benthic plants and animals (SAV and oysters) to rapid changes in salinity.

-determine relationship between freshwater inflow and nutrient loading of SLE.

-determine the original sources of carbon used by VEC of SLE using stable carbon isotope analsysis or biomarker methods.

-evaluate the impacts of MFL's on sediment accumulation in SLE.

LITERATURE CITED

Brand, L.E. 1984. The salinity tolerance of forty-six marine phytoplankton species. *Estuarine, Coastal and Shelf Science* 18:543-556.

Buskey, E. J., B. Wysor and C. Hyatt 1998. The role of hypersalinity in the persistence of the Texas "brown tide" bloom in the Laguna Madre. *Journal of Plankton Research* 20:1553-1565.

Chamberlain, R. and Hayward, D. 1996. Evaluation of water quality and monitoring in the St. Lucie Estuary, Florida. *Water Resources Bulletin* 32:681-696.

Doering, P.H. 1996. Temporal variability of water quality in the St. Lucie Estuary, South Florida. *Water Resources Bulletin* 32:1293-1306.

Farmer, L. 1980. Evidence for hyporegulation in the calanoid copepod, *Acartia tonsa*. *Comparative Biochemistry and Physiology* 65A:359-362.

Fry, B. and E. Sherr. 1984. Stable carbon isotope measurements as indicators of carbon flow in marine and freshwater ecosystems. *Contributions in Marine Science* 27:13-47.

Gillespie, M.C. 1971. Analysis and treatment of zooplankton of estuarine waters of Louisiana. Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana Phase IV. Biology. Louisiana Wildlife and Fisheries Commission, pp. 108-175.

Gunter, G. 1967. Some relationships of estuaries to the fisheries of the Gulf of Mexico. *In*: *Etuaries* (Publication No. 83) (Ed: Lauff, G.H.), American Association for the Advancement of Science, Washington, D.C., pp. 621-638.

Hackney, C.T., W.D. Burbanck and O.P. Hackney. 1976. Biological and physical dynamics of a Georgia tidal creek. *Chesapeake Science* 17:271-280.

Heinle, D.R. 1966. Production of a calanoid copepod, *Acartia tonsa*, in the Patuxent Estuary. *Chesapeake Science* 7:59-74.

Holmquist, J.G., J.M. Schmidt-Gengenbach and B.B. Yoshioka. 1998. High dams and marine-freshwater linkages: effects on native and introduced fauna in the Caribbean. *Conservation Biology* 12:621-630.

Hughes, D.A. 1969. Responses to salinity change as a tidal transport mechanism of pink shrimp, *Penaeus duorarum*. *Biological Bulletin* 136:43-53.

Kalke, R.D. 1981. The effects of freshwater inflow on salinity and zooplankton populations at four stations in the Nueces-Corpus Christi and Copano-Aransas Bay systems, Texas from October 1971 - May 1975. pg. 454-471. *In*: R.Cross and D. Williams (eds) Proceedings of the

National Symposium on Freshwater Flow to Estuaries, US Fish and Wildlife Service, Office Biological Service, Publication #FWS10BS-81/04.

Longley, W.L. (Ed). 1994. Freshwater inflows to Texas bays and estuaries: ecological relationships and methods for determination of needs. Texas Water Development Board and Texas Parks and Wildlife Department, Austin, TX. 386p.

Matthews, G.A. 1980. A study of the zooplankton assemblage of San Antonio Bay, Texas and the effects of river inflow on the composition and the persistence of this assemblage. PhD dissertation , Texas A&M University, College Station. 313 pp.

Nixon, S.W. 1981. Freshwater inputs and estuarine productivity. *In*: R.D. Cross and D.L. Williams (eds), Proceedings of the National Symposium on Freshwater Inflow to Estuaries. U.S. Fish and Wildlife Service, FWS/OBS-81/04. Washington D.C., Vol. 1, pp. 31-57.

Peebles, E.B. and S.E. Davis. 1989. Riverine discharge and estuarine fish nurseries: first annual report for the ichthyoplankton survey of the Little Manatee River, Florida. SWFWMD, Brooksville, FL.

Perez, K.T. 1969. An orthokinetic response to rates of salinity change in two estuarine fishes. *Ecology* 50:454-457.

Perez Farfante, I. and B. Kensley. 1997. Penaeoid and sergestoid shrimps and prawns of the world. Keys and diagnoses for the families and genera. Memoires du Museum National D'Histoire Naturalle, Tome 185 Zoologie, Editions du Museum, Paris. 233p.

Peterson, M.S. and S.T. Ross. 1991. Dynamics of littoral fishes and decapods along a coastal river-estuarine gradient. *Estuarine, Coastal and Shelf Science* 33:467-483.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1991. A list of common and scientific names of fishes from the United States and Canada. 4^{th} edition, American Fisheries Society, Special Publication No. 12. 174p.

Roddie, B.D., R.J.G. Leaky and A.J. Berry. 1984. Salinity-temperature tolerance and osmoregulation in *Eurytemora affinis* (Poppe) (Copepoda: Calanoida) in relation to its distribution in the zooplankton of the upper reaches of the Firth Estuary. *Journal of Experimental Marine Biology and Ecology* 79:191-211.

Rogers, S.G., T.E. Targett and S.B. Van Sant. 1984. Fish-nursery use in Georgia salt-marsh estuaries: the influence of springtime freshwater conditions. *Transactions of the American Fisheries Society* 113:595-606.

South Florida Water Management District (2001). Draft Technical Documentation to Support Development of Minimum Flows for the St. Lucie River and Estuary. Water Supply Division, SFWMD, West Palm Beach, Florida. 80p.

Suttle, C.A., J.A. Fuhrman and D.G. Capone. 1990. Rapid ammonium cycling and concentration-dependent partitioning of ammonium and phosphate: implications for carbon transfer in planktonic communities. *Limnology and Oceanography* 35:424-433.

Suttle, C.A., J.G. Stockner and P.J. Harrison. 1987. Effects of nutrient pulses on community structure and cell size of a freshwater phytoplankton assemblage in culture. *Canadian Journal of Fisheries and Aquatic Sciences* 44:1768-1774.

Suttle, C.A., J.G. Stockner, K.S. Shortreed and P.J. Harrison. 1988. Time-course of size-fractionated phosphate uptake: are larger cells better competitors for pulses of phosphate than smaller cells? *Oecologia* 74:571-576.

Szedlmayer, S. 1991. Distribution and abundance of nearshore fishes in the Anclote River estuary, west-central Florida. *Northeast Gulf Science* 12:75-82.

Sykes, J.E. and J.H. Finucane. 1966. Occurrence in Tampa Bay, Florida, of immature species dominant in Gulf of Mexico commercial fisheries. *Fishery Bulletin, U.S.* 65:369-379.

Turpin, D.H. and P.J. Harrison. 1980. Cell size manipulation in natural marine planktonic diatom communities. *Canadian Journal of Fisheries Aquatic Sciences* 37:1193-1195.

Wagner, C.M and H.M. Austin. 1999. Correspondence between environmental gradients and summer littoral fish assemblages in low salinity reaches of the Chesapeake Bay, USA. *Marine Ecology Progress Series* 177:197-212.

SFWMD RESPONSE TO THE SCIENTIFIC PEER REVIEW PANEL DRAFT REPORT

South Florida Water Management District (SFWMD or District) staff have reviewed the document entitled, *First Draft Final Report,* dated July 10, 2001, that was prepared by the scientific peer review panel to support development of minimum flows and levels (MFLs) for the St. Lucie River and Estuary. The panel spent a good deal of time and effort to review the materials provided, absorb the information presented, and compile this document in a short period of time. The analysis, comments, and suggestions provided will greatly improve our final work product. District staff particularly appreciate that the panel's comments were constructive, in the sense that issues or concerns were clearly identified and stated, and that constructive solutions or approaches to deal with these issues were also provided.

We agree in concept with most of the information and conclusions provided in the draft report. In several cases, we feel that the panel failed to adequately recognize or consider work that the District has done to address some of the issues raised. In retrospect, in most cases, the failure was not due to the panel's understanding, but rather to deficiencies in the report and supplemental information. Many of these issues have been addressed in this draft of the report. Additional information and better explanations of the issues raised by the panel have been provided.

This draft of the *Technical Documentation to Support Development of Minimum Flows for the St. Lucie River and Estuary* report includes both a copy of the panel's report and District staff responses to the specific comments and questions raised in the peer review report, including a description of how these issues were addressed in the revised technical document. A list of **Acronyms and Abbreviations** and a **Glossary** were added to ensure standardized terminology. Also, an **Executive Summary** targeted for lay readers and nonscientists has also been added.

In general, the panel focused on three major areas where additional information was needed. These were salinity modeling, water quality, and developing a better linkage between the oligohaline zone and enhancement of valued ecosystem components (VECs) in the St. Lucie River and Estuary. While, staff has included some additional information and clarified some of these issues, additional efforts will be needed to further analyze historical data sets and collect new data to provide adequate treatment of these concerns. Such efforts were not feasible within the time frame of the current MFL development process and will need to be provided in future updates.

One especially important point is that the report needs to emphasize the "adaptive management approach" to developing and implementing these MFLs. While District staff implicitly understood that the adaptive approach was the basis for our proposed management strategy, we failed to use that terminology in the report.

Panel chairman Dr. Mark Peterson noted that "none of the District's comments required modification of the final document." Therefore, the scientific peer review panel's final report remained unchanged from the *First Draft Final Report*. Specific issues and recommendations included in the panel's final report relating to the development and documentation of technical criteria are itemized below. Responses to panel concerns are addressed either in this appendix or within the body of the revised document. In the latter case, reference will be made to the appropriate section.

Issues

- Model linkage not adequately explained
- Lack of direct evidence connecting oligohaline zone to tangible VEC enhancement
- Lack of discussion on water quality impact
- Clarification of the terms harm, significant harm, and serious harm
- Minor editorial corrections

Recommendations

- Additional salinity modeling results need to be presented to document model calibration using available salinity data
- Implement adaptive management strategy to further develop minimum flow requirements
- Develop water quality model to address MFL related questions
- Establish a research plan to fill critical information gaps. Future investigations should do the following:
    - Compare primary productivity and phytoplankton biomass of the St. Lucie Estuary oligohaline and mesohaline zones
    - Compare zooplankton biomass in the St. Lucie Estuary oligohaline and mesohaline zones
    - Investigate tolerances of sedentary benthic plants and animals (submerged aquatic vegetation and oysters) to rapid changes in salinity
    - Determine the relationship between freshwater inflow and nutrient loading
    - Determine the original sources of carbon used by VECs of the St. Lucie Estuary using stable carbon isotope analysis and biomarker methods
    - Evaluate the impacts of MFLs on sediment accumulation in the St. Lucie Estuary

Response to Issues

Model Linkage Not Adequately Explained

Chapter Four's section on **Hydrologic and Hydrodynamic Modeling** was revised to improve descriptions of, and interactions among, models used in the hydrologic evaluation of the St. Lucie River and Estuary watershed.

Lack of Direct Evidence Connecting Oligohaline Zone to Tangible VEC Enhancement

The loss of low salinity habitat (oligohaline zone) in the St. Lucie Estuary was chosen as an indicator of significant harm for the estuary. One of the major justifications for using this habitat as a VEC was its importance to the life history of many fish species. A list of species from the literature that may be affected by the loss of this habitat was provided. The review panel indicated that additional information regarding endemic species was needed from available literature in order to provide the evidence needed for connecting oligohaline zone protection to tangible VEC enhancement. The list in Chapter 4 (**Table 9**) was expanded to include species collected in low salinities during the dry season in the St. Lucie Estuary. An additional discussion of VEC species and relationships to oligohaline habitat entitled **Proposed Valued Ecosystem Component for the St. Lucie Estuary** was included in Chapter 4.

Lack of Discussion on Water Quality Impact

Water quality impacts are more appropriately addressed in the *Indian River Lagoon Surface Water Improvement and Management (SWIM) Plan* (Steward et al., 1994), which is currently being updated. However, understanding that water quality is an area of critical concern to the river and estuary, this document has been revised to include a more detailed discussion of water quality issues and monitoring efforts in Chapters 2, 3, and 4 (**pages 26**, **47**, and **69**, respectively), including discussions regarding the effects of minimum flows on water quality.

Clarification of Terms

The legal definition of harm, significant harm, and serious harm is provided in the **Level of Protection for Water Resource Functions Provided by the MFL Standard of Significant Harm** section in Chapter 1. Minimum flows and levels relate to the significant harm standard. This standard is defined in terms of the duration of the recovery period, which is the “temporary loss of water resource functions... that takes more than two years to recover.” The relationship of minimum flows to significant harm in the St. Lucie Estuary is defined in the **Proposed Criteria** section in Chapter 6. It is assumed in this definition that the duration of the recovery period is measured from the point at which harm first occurs.

Response to Panel Recommendations

Additional Salinity Modeling Results Should Be Presented to Document Model Calibration Using Available Salinity Data

The recalibration effort continues as new data sets become available. Florida Department of Environmental Protection (FDEP) data was used in the current recalibration simulation, results of which are expected to be available in November 2001. The following is a summary of this effort to date.

On page 3 of review panel's final report, it was recommended that, ". . . additional modeling results of salinity [should] be presented in the Final Technical Documentation to document model calibration using available salinity data. Quantitative assessment of the goodness-of-fit between the model results and salinity data must be included." Based on this recommendations, further calibration of the hydrodynamic and salinity model has been undertaken. The calibration data set covered a 2.5-month period from September 1999 to December 1999. Water level was measured every 15 minutes at the St. Lucie Inlet by FDEP. Salinity and water level were measured at the A1A, Roosevelt, and Kellstadt Bridges. Velocity was also measured at the Kellstadt Bridge. Inlet water level data were compared to 1998 calibration data and data from the National Ocean and Atmosphere Administration tide books to determine necessary corrections. These corrected data were then used as boundary conditions for the model. Lake of velocity measurement data at A1A and Roosevelt Bridge restricted the calibration at these two stations.

Lack of bathymetry data and inadequate flow data on the North Fork of the St. Lucie River further restricts calibration. Currently, discharge to the North Fork is estimated from Gordy Road Structure flow and the ratio between the two drainage basin areas. Calibration of velocity and salinity will continue. Further efforts will explore the available data to reach this goal.

Long-Term Simulation

On page 9 (second paragraph) of the review panel's final report the following recommendation is made: "An ideal simulation scenario to fully validate the hydrologic and hydrodynamic model simulations would be to perform a 10-year simulation to reproduce the long-term salinity data from 1989 to 1999. Salinity data are available from the SWIM program for the St. Lucie River Estuary."

The SWIM data collection program was designed for monitoring purposes. A measurement was made each month to detect the general level of salinity in the estuary. The data does not contain any time series data and does not describe the salinity variations over tidal cycles. Also, that data set does not have concurrent tidal data. While the SWIM water quality monitoring is an excellent and productive program, the salinity measurements were not intended for a hydrodynamic/salinity model validation.

In order to obtain concurrent time series data for model development, the SFWMD established a network of continuous recording stations in the St. Lucie Estuary in 1997.

The stations recorded concurrent tide/salinity/temperature data at 15 minutes intervals. The data collected in the period from November 1997 to June 1998 was used for the preliminary calibration of the St. Lucie Estuary RMA Hydrodynamics/Salinity Model.

A difficulty we had during the model development was that we did not have flow records for the South and North Forks and Basins 4, 5, and 6. In the November 1997 to June 1998 simulation, we had to use the estimated runoff for those watersheds. The runoff was provided by Lead Engineer Steve Lin using the Hydrologic Simulation Program-FORTRAN (HSPF). We intend to extend the watershed model simulation to the period from June 1998 to the end of 2000 so that we can extend the hydrodynamic/salinity model verification to the same length.

Implement an Adaptive Management Strategy to Further Develop Minimum Flow Requirements

Although an adaptive management approach including setting targets, monitoring, analysis, and reevaluation was implied in the draft technical document, it was not expressly stated as such. Appropriate sections have been revised to more clearly define the adaptive management strategy approach in the development of the St. Lucie River and Estuary MFLs.

Develop Water Quality Model to Address MFL Related Questions

The District has a water quality modeling program in place for the St. Lucie Estuary. It is primarily designed to support issues raised in the SWIM program, including the development of pollution load reduction goals (PLRGs) and total maximum daily loads (TMDLs) for the river and estuary. A brief description of this modeling effort is included in the **Research Strategy** section of Chapter 6. This model can also be applied to address issues raised by the peer review panel. For example, it can be applied to ensure that the minimum flows provided to the St. Lucie Estuary provide sufficient nutrients to maintain aquatic productivity in the estuary and the adjacent Indian River Lagoon.

Establish a Research Plan to Fill Critical Information Gaps

The St. Lucie MFL provides for an oligohaline zone in the North Fork of the estuary. The use of the oligohaline zone as the VEC upon which to base the MFL depends on the following assumptions:

- First, oligohaline zones of estuaries provide critical nursery habitat for important estuarine dependent species.
- Second, an oligohaline zone in the North Fork is beneficial to the estuary.

The first assumption is general and based on widely accepted concepts supported by the peer reviewed scientific literature. The second assumption is site specific and not well supported by site specific information. The peer review report states, “Without knowing how much (or when) oligohaline habitat is required to maintain or enhance productivity in the St. Lucie Estuary, there is no clear, compelling minimum flow rate. "The peer review report recommends that a monitoring program be instituted to evaluate the connection of the oligohaline zone and the VECs, water quality impacts, and the importance of freshwater flow to the estuary in addition to its role of controlling salinity. A number of specific projects were suggested:

- Compare primary productivity and phytoplankton biomass of the oligohaline and mesohaline zones of the St. Lucie Estuary
- Compare zooplankton biomass in the oligohaline and mesohaline zones of the St. Lucie Estuary
- Investigate tolerances of sedentary benthic plants and animals (submerged aquatic vegetation and oysters) to rapid changes in salinity
- Determine the relationship between freshwater inflow and nutrient loading of the St. Lucie Estuary
- Determine the original sources of carbon used by the VECs of the St. Lucie Estuary using stable carbon isotope analysis and biomarker methods
- Evaluate the impacts of MFLs on sediment accumulation in the St. Lucie Estuary

Both ongoing research, conducted by the District, and that planned for the future, incorporate many of the aspects of the specific projects listed above and the general areas of deficiency identified by the panel. Chapter 6 has been revised to include research priorities for continued MFL development.